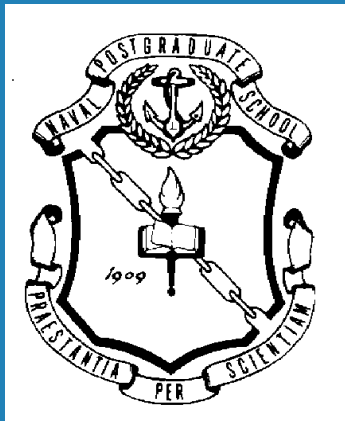


Human Factors in Maintenance



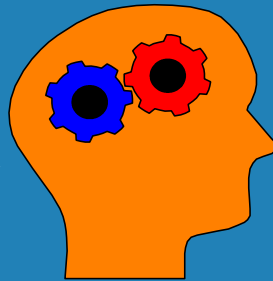
CDR John K. Schmidt, PhD MSC USN
ASST PROF, School of Aviation Safety
U. S. NAVAL POSTGRADUATE SCHOOL

HFQMB - Human Factors Quality Management Board

Mishap Data
Analysis

Benchmarking

Safety
Climate
Assessment



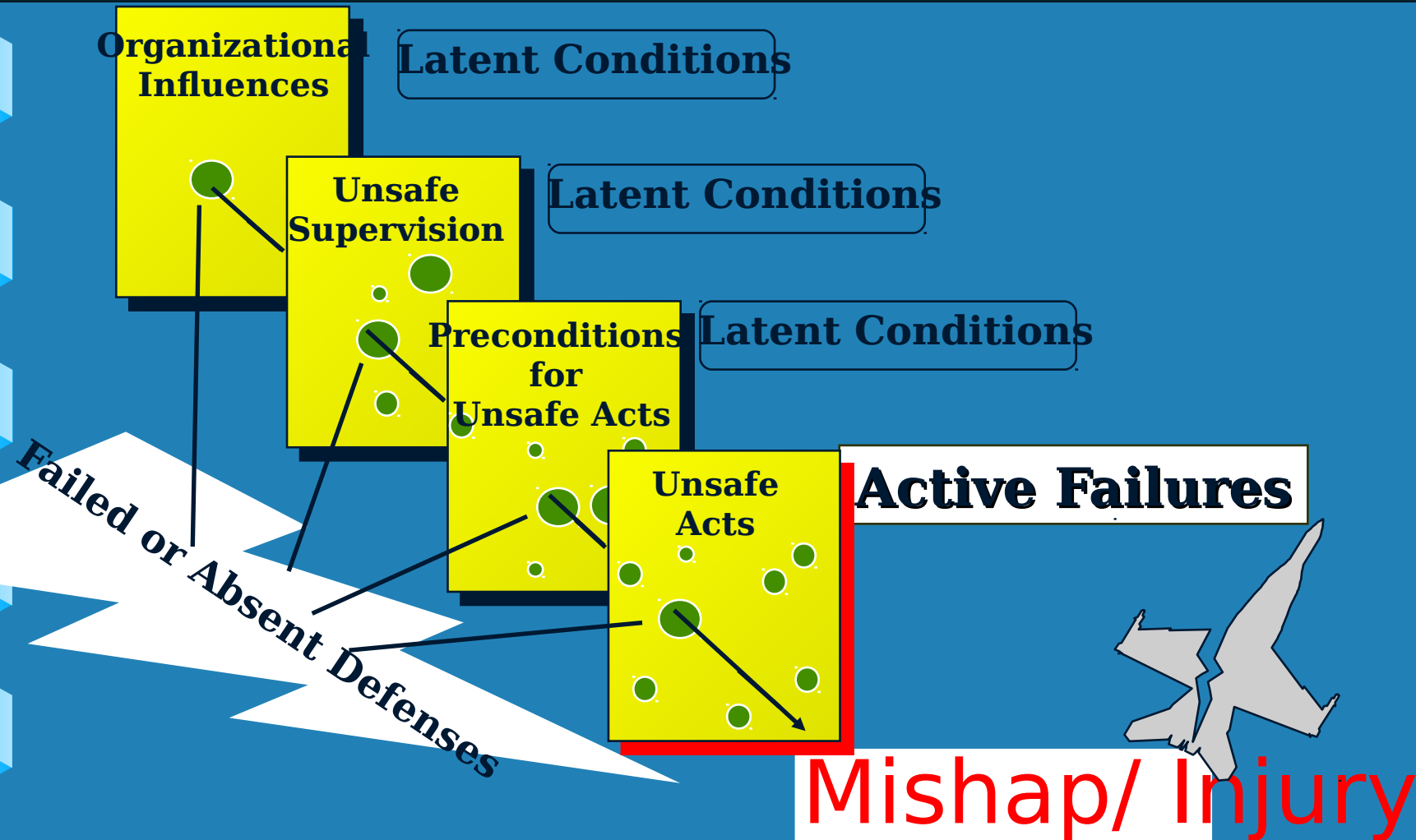
Brainstormin
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Recommendati
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Intervention

HFQMB Maintenance PAT Schedule

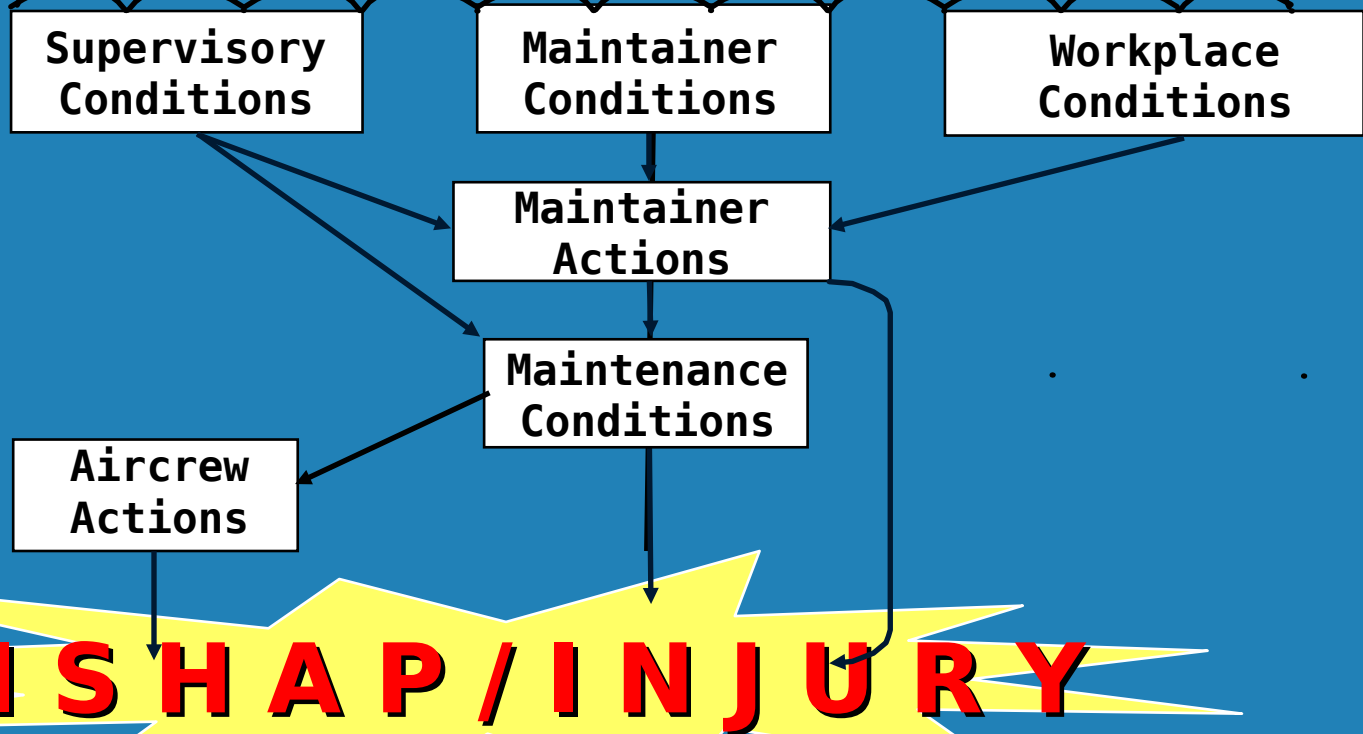
- ⦿ Mishap Data Analysis 10/97 - 6/98
- ▮ **Mishap Data Packages 12/98**
- ▮ Benchmark Visits 1/98 - 12/98
- ▮ **Lessons Learned 12/98**
- ▮ Survey Development 2/98 - 5/98
- ▮ Pilot Survey & Analysis 3/98 - 7/98
- ▮ **Report Preliminary Results 8/98**
- ▮ Survey Ready/Distributed 9/98 - 10/98
- ▮ Survey Data Analysis 10/98 - 12/98
- ▮ **PAT Recommendations 12/98**

Reason's "Swiss Cheese" Model



Human Factors Accident Classification System (HFACS): Maintenance Extension

ORGANIZATIONAL CLIMATE



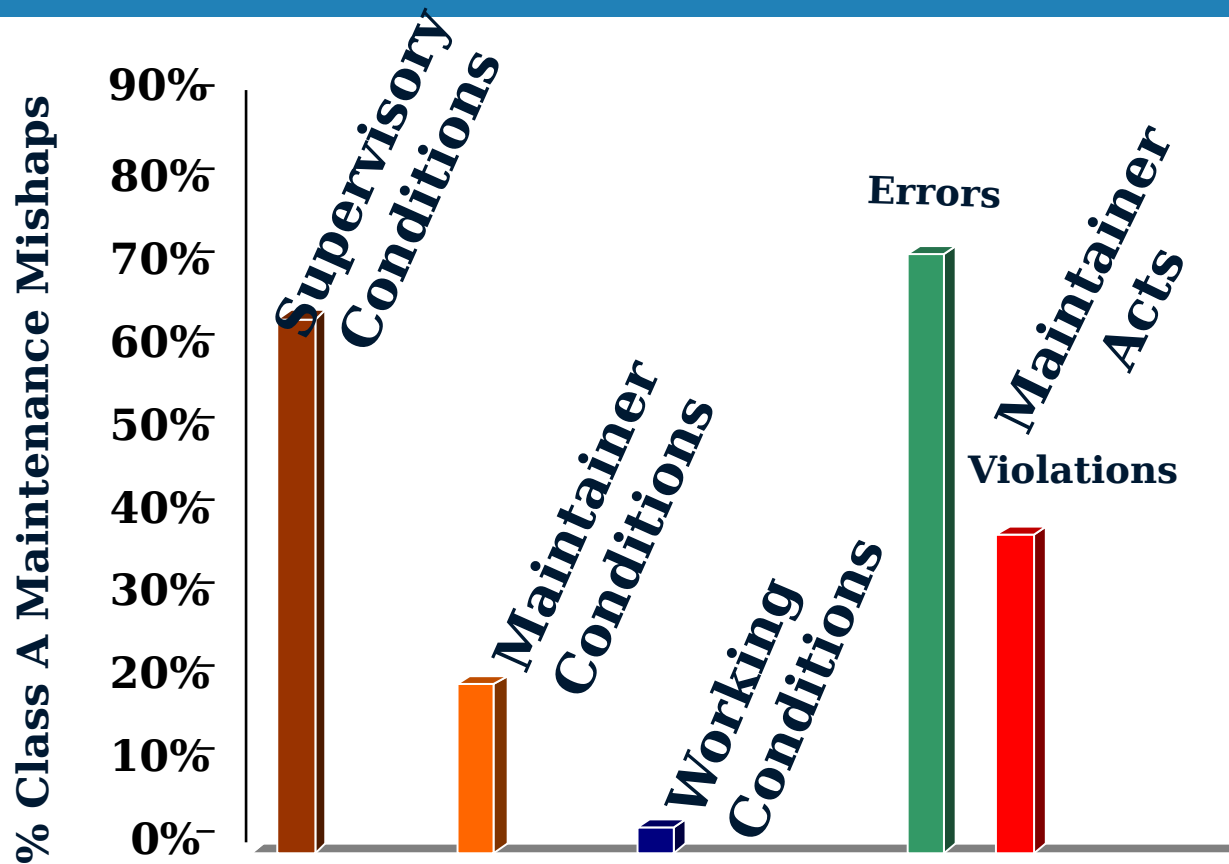
Human Factors in Class A Maintenance Related Mishaps (FY 90-97)

- 63 Maintenance Related Class A Mishaps Were Analyzed For Human Error Causes

Classification Process Performed by Naval Maintenance Personnel



Human Factors Analysis of Class A Maintenance Related Mishaps (FY 90-97)



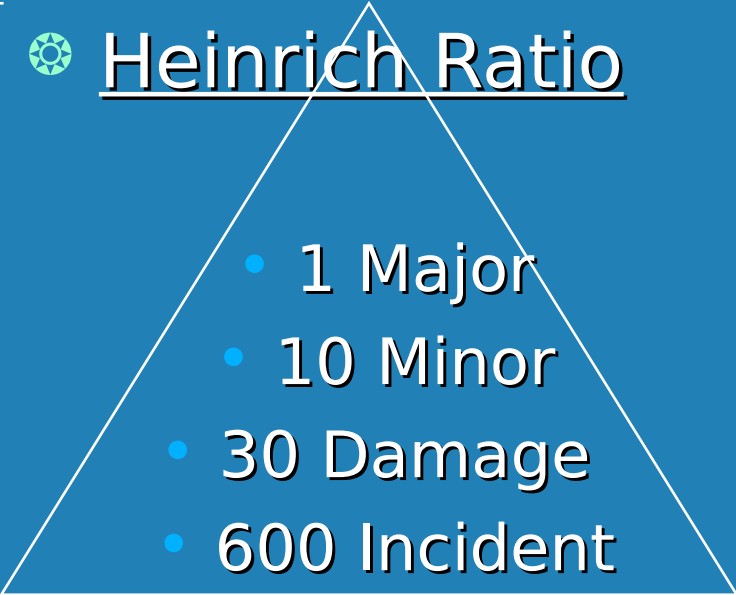
General Findings

- ❁ **Miscommunication - supervisor to subordinate, pass-down, or shift turnover**
- ▢ **Not using, lack of, or outdated publications**
- ▢ **Poor/Non-existent maintenance procedures**
- ▢ **Violations- not following li**



Major Vs. Minor Events

☼ Heinrich Ratio

- 
- 1 Major
 - 10 Minor
 - 30 Damage
 - 600 Incident

☼ Naval Aviation Events

- Class A Mishaps - 40
- Class B Mishaps - 30
- Class C Mishaps - 180
- Hazards Reports - 2500

Commercial Airline Maintenance Issues

- ⚙ 1997 Boeing reported 6% of worldwide airline mishaps are primarily due to maintenance*
- ⚙ 1997 Boeing reported maintenance error contributed to 15% of commercial jet mishaps
 - ▮ 20% of in-flight engine shut downs are attributable to maintenance error
 - ▮ 50% engine related delays and cancellations are due to maintenance error

*(Does not include Pushback/Hit by Vehicle/Servicing Mishaps)

(Source: Boeing, 1997; Marx, 1999)

Operations for Human Factors Analysis



⚙ **Maintenance Activities**

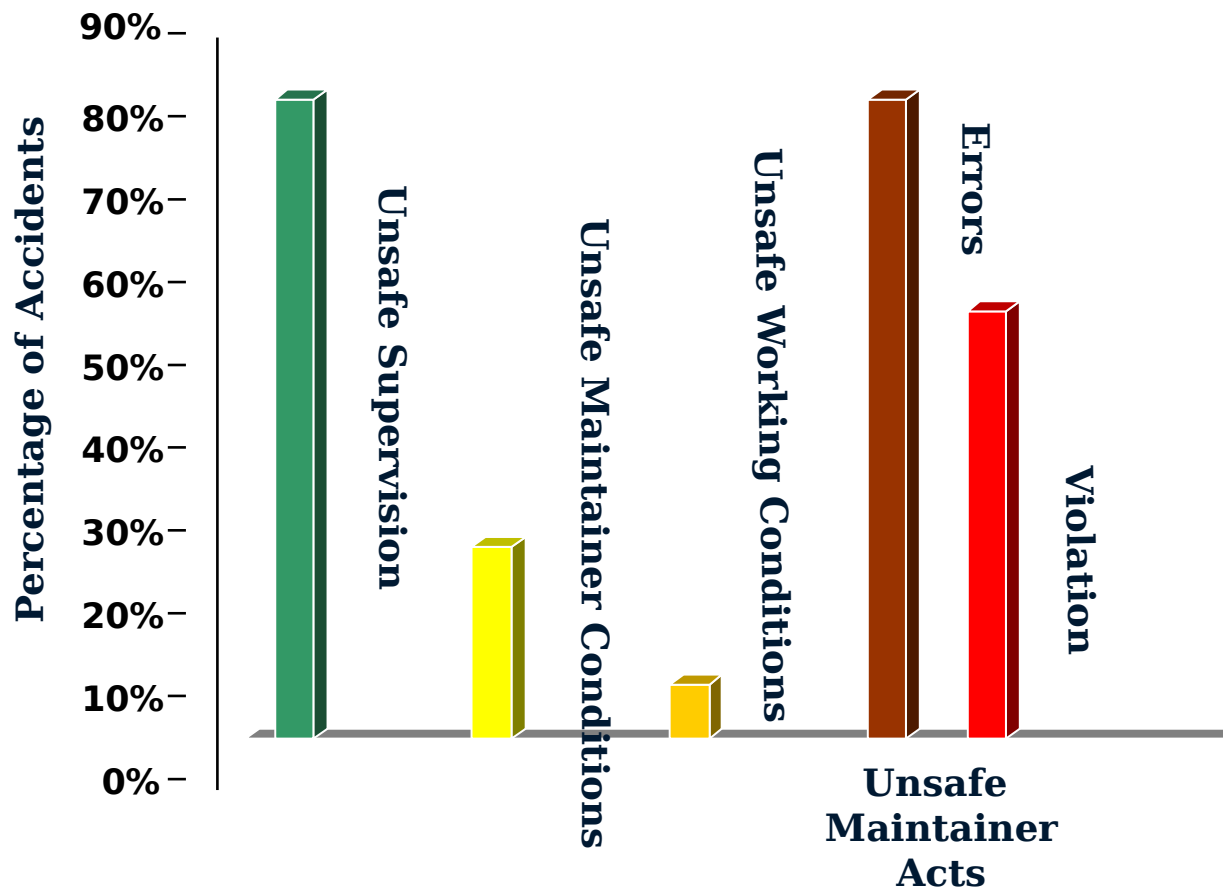


▢ **Ramp/Line Activities**



▢ **Ordnance/Stores Activities**

F/A-18 Maintenance Related Mishaps (FY 1990-1997)



UNSAFE SUPERVISION

NAVAIR/TYCOM/DEPOT

SQDRN

- INADQ DOC/PROC
 - ▣ Inadequate Design
 - ▣ Unrecognized REQ

- ▣ Failed to Provide QA/INSP
- ▣ Failed to Provide/INADQ TRNG
- ▣ INADQ/Failed Supervision
- ▣ Permitted Unnecessary Hazard
- ▣ Failed to Ensure Qual/Cert.
- ▣ INADQ/NO PROC in Place
- ▣ Supervisory Violation



Editor's Note: The lower level percentages do not add up to 100% because more than one lower level factor may have been present in a given mishap.

UNSAFE MAINTAINER CONDITIONS

Medical

C R M

**Readine
ss**

▣ No Medical Factors Listed;
Likely present but not reported

▣ Imp/Misinterp.Hand Signa
▣ Did Not CoCOMM MSG/Stat
▣ Failed to ADQ Brief

▣ Use of Controlled Substan
▣ Few Readiness Factors Lis
Likely present but not r

Editor's Note: The lower level percentages do not add up to 100% because more than one lower level factor may have been present in a given mishap.



UNSAFE WORKING CONDITIONS

Tools & Equipme nt

Space & Layout

Environme nt

▣ Lacked ADQ Equipment
▣ Few Tools & Equipment Factors;
Likely present but not reported

▣ No Space & Layout Factors;
Likely present but not reported

▣ No Environment Factors;
Likely present but not reported

Editor's Note: The lower level percentages do not add up to 100% because more than one lower level factor may have been present in a given mishap.



UNSAFE MAINTAINER ACTS

Errors

- ▣ GSE Left Unattended
- ▣ Improper Install/Load
- ▣ Failed to Secure
- ▣ Wrong Procedure
- ▣ INADQ Inspection
- ▣ Inattention/Clearance
- ▣ Over/Under Torque
- ▣ Lost Control GSE
- ▣ Failed to Tow Properly

Violations

- ▣ Failed to Perform Inspection
- ▣ Used Improper Procedure
- ▣ Did Not Use PUB/Manual
- ▣ Maintainer Unqualified
- ▣ Failed to Take Action
- ▣ Permitted Unsafe Act
- ▣ Failed to Follow Verbal INST

Editor's Note: The lower level percentages do not add up to 100% because more than one lower level factor may have been present in a given mishap.



Airline Maintenance Errors

- ⚙ Incorrect installation of components
 - ▮ Fitting the wrong parts
 - ▮ Electrical wiring discrepancies
 - ▮ Loose objects left in the aircraft
 - ▮ Inadequate lubrication
 - ▮ Cowlings, access panels, and fairing not secured
 - ▮ Fuel/oil caps and refuel panels not secure
 - ▮ Landing gear lock pins not removed before departure

(Source: Johnson et al, 199

Incident Contributory Factors

- ⦿ Not following regulations or procedures
 - ▮ Equipment misuse or equipment defects
 - ▮ Organizational (supervision/discipline)
 - ▮ Behavior (misjudgment/misperception)
 - ▮ Physical Circumstances (Wx, night, etc.)

(Source: Johnson et al, 1994)



FEDERAL AVIATION ADMINISTRATION

Human Factors in Aviation Maintenance and Inspection Research Program

Primary Activities

- **Maintenance Resource Management**
- **Maintenance Error Reduction**
- **Job Task Analysis in Maintenance**
- **Maintenance and Inspection Training**
- **Job Aids for Maintenance and Inspection**
- **Information Dissemination**
- **Communication and Harmonization**

(Source: FAA, 1998)

Maintenance Resource Management (MRM)

Continental Airlines initiated a Crew Coordination

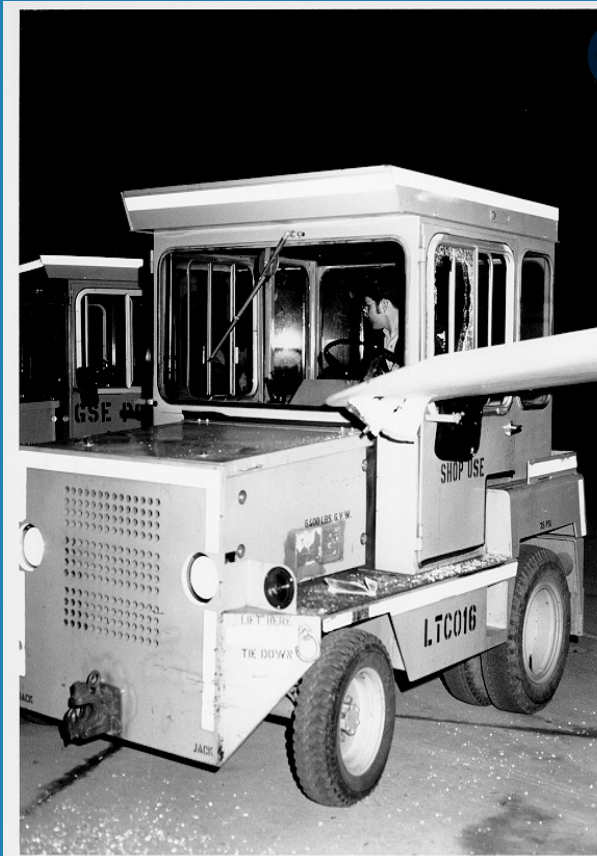
Concepts program *“to equip all maintenance personnel with the skill to use all resources to improve safety and efficiency.”*

First year results were remarkable:

- **2200 employees received training (2/3 workforce)**

(Source: FAA, 1998)

Naval Aviation MRM: GCT - Groundcrew Coordination Training



GCT Related Statistics:

- Using Determined Causal Factors
(All Maintenance Related Mishaps)
 - 12.8% of all Class A /B Mishaps
 - 33.8% of all AGMs
 - MRM Mishap Costs= \$58.3 Million
- Using Procedural Analysis (Ramp)
 - Almost **50%** of all Class A /B Mishaps
 - Almost **70%** of all AGMs
 - Over **50%** of Personal Injuries

Maintenance Safety Culture Assessment

- ⦿ Developed Prototype Survey w/ AIRPAC
- ▮ Pilot Tested Survey w/ VP-91, VR-57, & HC-85
- ▮ Final Version for Fleet Validation This Fall
- ▮ Tailoring for USMC Units Planned

Benchmarking VR Community Maintenance Operations



Navy's Organic Passenger & Cargo Carrier Aircraft Include C-9s, C-12s, C-20s, C-130s





Benchmarking VR Community Maintenance Operations

- ⦿ Analysis of Fleet Support Wing MISREPS & HAZREPS using HFACS, MEDA & THEA to Identify Human Factors Issues and Trends
- ▮ Development of VR Operational Risk Management Program
- ▮ Maintenance Safety Climate Survey of all Wing Squadrons
- ▮ Groundcrew Coordination Training to all Wing Squadrons



SAFETY QMB

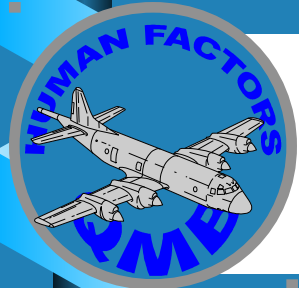
Aircraft Maintenance
Human Factors PAT

**Recommendations from
CAPT(SEL) Michael D.
Hardee
24 August 1998**



Recommendations

- ☼ **Implement Ground Crew Coordination Training (GCT)**
- ▮ **Implement maintenance oriented Operational Risk Management (ORM)**
- ▮ **Enhance Mishap Investigation and Reporting**
- ▮ **Improve Maintenance Personnel Management**

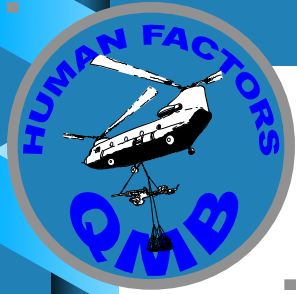


Recommendations

☼ Implement Organizational Assessment Survey and Decision Support Tools

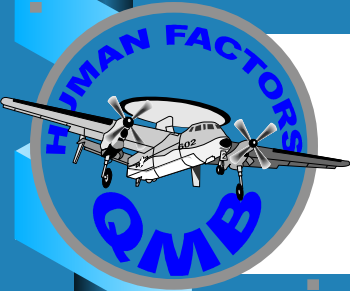
▮ PAT Membership

- CNAP/CNAL N452
- CNAP/CNAL N422C
- CNAP/CNAL N422F
- NPS
- CNSC
- CNET
- CNAP 1094 (Reserve component attached to N422)



Future Direction

- ❁ **PAT chartered to provide POAM for:**
 - **resources to implement stated recommendations**
 - **continue to seek new methods of maintenance error reduction**
 - **continued benchmarking with and contributing to the commercial aviation industry**



Recommendations

⚙️ Operational Risk Management

Seamless imbedding of ORM to yield change in paradigm by:

- Instituting maintenance oriented ORM in maintenance policy
- OPNAV, TYCOM and TYPEWING policy and instructions
- Imbed ORM in AMTCS and FASO courses
- Formalize maintenance oriented ORM in NAMTRA and local squadron training, such as GCT

▢ Ground Crew Coordination Training

- Course developed by Aviation Safety School @ NPS
- Best intervention strategy
- Implement within NAMTRA & WING training curricula
- Tailor and target senior enlisted personnel
- Tailor for entry level in core & strand training



Recommendations

Mishap Investigation and Reporting

- **Modify current OPNAV 3750 mishap investigative procedures to include detail capture of maintenance human factors**
- **Enhance HFACS model for applicability to Maintenance Crews and Maintenance Operations**

Maintenance Personnel Management

- **Increase close-loop detailing of T/M/S community expertise**
- **Assure assignment of experienced and trained personnel to appropriate T/M/S**
- **Type Wing maintenance/manpower staff to retain most experienced personnel within community**



Recommendations

- **Organizational Assessment Survey (OAS) & Decision Support Tools**
 - Implement OAS as decision support tool/indicator for safety climate assessment at squadron level
 - Survey in final development by NPS; implement within VR community